DOCUMENT RESUME

ED 171 818 UD 019 320

AUTHOR Cussler, E. L.
TITLE An Alternative Route to Chemical Engineering for Minority and Other Students.
PUB DATE 78
NOTE 5p.

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Accelerated Courses; *Chemistry; Course Content; Engineering Education; Graduate Students; *Graduate Study; Higher Education; *Minority Groups; *Summer Science Programs
IDENTIFIERS *Carnegie Mellon University PA; *Chemical Engineering; University of Virginia

ABSTRACT

The following three alternative ways in which minority group chemistry majors may be trained as chemical engineers are examined in this paper: (1) they are admitted as engineers and take the same courses as engineering students at the graduate level; (2) undergraduate courses are taken as part of the transition from chemistry to chemical engineering; and (3) special undergraduate engineering curriculum courses are taken during the summer prior to entry into the graduate program. The disadvantages of the first two approaches are outlined. The characteristics of the successful accelerated summer course program at Carnegie-Mellon University are discussed. (MC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

By: E. L. Cussler

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
E.L. Cussler

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED171818

An Alternative Route To Chemical Engineering For Minority And Other Students

When times are good, college students tend to be interested in education. They study subjects because of inherent interest, without regard for the utility of what is learned. When times are unsettled, college students become much more interested in professional training. They believe that such professional education will facilitate employment. They often choose to study engineering because it provides one of the fastest routes to a professional degree.

Because times are currently unsettled, many students who have majored in chemistry as undergraduates are now interested in graduate study in chemical engineering. Moreover, many chemical engineering graduate programs could use a greater number of qualified students. When programs see the more than ample supply of chemists available, the lure is obvious: why not teach chemical engineering to chemists? This essay explores the ways in which this teaching can be effectively accomplished. It explores what programs exist to do this, and how they are operated.

Edward L. Cussler has received wide recognition for his research and teaching. He received the Allan P. Colburn award from the American Institute of Chemical Engineers for excellence in publications in 1975; a year earlier Cussler was singled out to receive the university-wide Ryan Award for Meritorius Teaching at Carnegie-Mellon. His research interests range from the development of thin-skinned artificial membranes to prediction of cosmetics texture from analysis of chemical composition.

UD019320

Three Programs

The education of chemists as chemical engineers can be roughly organized into three methods.

Open Admissions

In this first method, one simply denies any difference: One admits chemists as engineers and has them take the same courses as engineering students. Such flexibility has a long tradition; almost every senior professor can remember a few individuals in the 1930's and 1940's who made such a transition. Moreover, it has the tremendous appeal of requiring little extra work, either by faculty or by the administration.

However, we are concerned about this method because we believe it significantly changes the education of the graduates. If more than a third of a graduate-level class is not trained in chemical engineering, the technical level of the material taught drops. Moreover, because the current trend in many departments is to reduce graduate-level course requirements, one may end up certifying "engineering" graduates who know very little engineering.

The common alternative to open admissions is a program which requires undergraduate courses as part of the transition from chemistry to chemical engineering.

in industry and to their employers, and received information about how the students compared to graduates of normal programs. Primarily we learned that those trained in chemistry have a more pragmatic attitude than those trained in

". . . Primarily we learned that those trained in chemistry have a more pragmatic attitude than those trained in engineering."

While the number of courses in such programs varies considerably, all include courses in transport phenomena, and most require thermodynamics. After completing these courses, the chemist enters the conventional graduate program. The cost to the University is minor, since no new courses are involved. Such requirements certainly insure a solid engineering education of both breadth and depth, so that graduates can be fully employed as chemical engineers.

There are, however, drawbacks to this kind of program too. First of all, it is too demanding: in the Texas A&M program, for example, only 25-30% of the students originally admitted later graduate. Another drawback is that few students can afford to undertake extensive remedial work at their own expense.

Undergraduate Remedial Work

The third way of teaching chemical engineering to chemists is to require special courses giving an accelerated synopsis of the undergraduate engineering curriculum. This is the strategy used at CMU in our "New Alternatives" program, and at the University of Virginia, and it is the one with which we are most sympathetic. Because of the accelerated nature of such a program, its brighter graduates quickly qualify for research support on government grants and contracts. The transition to engineering is also smoother in this type of program than in the others, since 70% of the entering students complete their degrees. The major difference, however, is that these graduates are not chemical engineers, but a new breed, armed with a new mixture of skills. The implications are explored below.

We sent questionnaires to the graduates of these special programs who are employed

engineering. For example, these students complain that the Masters level courses are too theoretical, while students with an engineering background feel the same courses are excessively practical. Apparently, those who move from chemistry into engineering make a mature and conscientious decision that their future lies in an industrial environment. They are very sensitive to industrial demands and respond accordingly. On the other hand, those trained in engineering often go to graduate school--in part because they are anxious to learn more of the intellectual basis of their discipline. This basis is more strongly represented in universities than in industry.

Rather than situating themselves, as in universities, at the end of a spectrum of chemistry and chemical engineering, industrial jobs require training along that spectrum. However, industry recruits within the departmental structure and recruiters do not seek specific individuals but people with specific types of certification. The students are being hired as engineers, but are working as hybrids.

Educational Characteristics of the Special Programs

The accelerated programs at CMU and at the University of Virginia are an educational innovation. They each consume about eight weeks of the summer before the Master's year, and they commonly have three hours of lecture per day, five days a week (the students at CMU joke that the freshman year takes one week, the sophomore year two weeks, and the junior and senior years three weeks apiece). The programs also have at least one problem-solving session every day, and many of these sessions run overtime.

Meg Qamos and Lee McCoy are currently involved in CMU's "New Alternatives" program.

Educational Characteristics of the Special Programs

The accelerated summer course at CMU lasts 8 weeks and covers sequentially the following materials: stoichiometry, thermodynamics, equilibrium stages, fluid mechanics, heat transfer, and mass transfer (a senior level design course is also required during the academic year, and kinetics is often taken as an overload). The summer program at the University of Virginia lasts nine weeks and consists of two parallel courses. The first course covers mathematics, fluid mechanics and heat transfer; the second covers heat transfer, mass transfer, and kinetics.

We have discovered at CMU, somewhat to our surprise, that the plethora of topics listed above can be effectively covered. To test this, we gave the same exams both to undergraduates and to students in the program. The students in the program easily outscored the undergraduates. This is a result of the students' quality, their maturity, and their dedication to making an effective transition.

The chemists have the most trouble in two areas: mathematics and thermodynamics. Mathematics presents an old problem: while most students have studied differential equations, few can apply what they've learned to physical situations. Virginia's program teaches mathematics directly; ours relies on graduate-level mathematics courses taken in the fall semester. In contrast, the students' deficiency in thermodynamics is less expected and harder to rectify. While most of the students in the two programs are graduates of ACS-accredited chemistry departments, all of which teach a required thermodynamics course, most of the students claim to have had little or no thermodynamics. But we think the truth is probably closer to what one student said: "Sure, I had all this stuff but no one ever acted like it was important."

At CMU, we have tried to remedy this deficiency in thermodynamics by including material in the summer course. We have not yet been able to teach this material effectively, partly because an extremely abstract subject is being presented at a very rapid rate. Our students have been able to handle a graduate course in thermodynamics in the fall semester, but the experience has been trying, demanding, and unpleasant.

We've had two other problems with our special summer course which deserve mention. The first is that we have not been able to find an effective text. Chemical engineering is almost completely taught in a sequential fashion and everyone who studies sophomore thermodynamics intends to take the junior-level transport phenomena courses and the senior-level kinetics courses). This means that there is no available text that provides an abbreviated overview of the essentials of chemical engineering in relatively simple terms. As a consequence, we have had to write a text, which we would be glad to make available to other teachers with similar needs.

The second problem we have had concerns retaining minority students in the program. Both they and students who have been out of college three or more years find the required mathematics to be extremely difficult. As a result, we have preceded our special summer course with a one-week mathematics review, taught by people connected with our minority engineering program. This has two results: it provides the minority and the returning student with the necessary mathematics and it also establishes firm friendships between these two groups. When the rest of the class convenes, the black students do not isolate themselves as frequently occurs in undergraduate classes.

At present, there is a greater demand than supply for female and minority students trained in engineering, but it is foolish to put women or minority group members into positions they are not competent to fill. This does no one any favors --not the misplaced person who is set up to fail, nor the dubious co-workers who use this example as a self-fulfilling prophecy for their prejudices. A program like the "New Alternatives" program at CMU provides a trial, even if by fire, and can give able people some of the preparation they need for newly available jobs.

We should emphasize that special summer courses are not substitutes for undergraduate training in chemical engineering. It merely facilitates the students' ability to catch up during the regular academic year. Although students whose backgrounds are in chemistry do less well relative to their classmates during the fall courses, by spring this difference disappears. In other words, the special summer course does not substitute for undergraduate training, but does allow students with different backgrounds to become competitive. A student who completes this course probably has been exposed to as much chemical engineering as a conventional chemical engineer remembers; however, the "New Alternatives" student will not have as strong a perspective since such a perspective can only be learned over a longer period of time. But, the special summer course has proved to be an effective testing ground. Although 20% of the students have dropped out, or been asked to leave, at the end of this period, virtually everyone who starts in the fall has been able to compete effectively with our regular graduate level engineering students and to complete the program successfully.

". . . A program like the "New Alternatives" Program at CMU provides a trial, even if by fire, and can give able people some of the preparation they need for newly available jobs."